Adaptation Model of Rice Paddy Farmers in Reducing the Impact of Weather Change Case Study in Karanganyar Village, Deli Serdang Regency, Indonesia

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Abstract: Extreme climate change affects global food security, especially in developing countries. Rising temperatures, erratic rainfall, and the frequency of natural disasters such as floods and droughts reduce agricultural productivity, affect food quality and increase production costs. In Indonesia, these impacts exacerbate poverty and food insecurity. This study aims to analyze the impact of climate change on rice productivity and evaluate farmers' adaptation to organic, semi-organic, and inorganic approaches to improve food security. This research uses qualitative methods to understand farmers' perceptions, vulnerabilities, and adaptations to climate change in depth. Data collection techniques were conducted through in-depth interviews, participatory observation, documentation, and literature study to understand farmers' experiences and strategies. Data analysis techniques in this study followed Denzin's stages: collection, coding, theme search, critical interpretation, and contextual report writing. The research shows that wetland rice farmers in Karanganyar Village face the impacts of climate change with various adaptation approaches. Organic farmers focus more on ecosystem sustainability and local wisdom, while inorganic farmers rely on chemical inputs and modern technology, which increases environmental risks. Semi-organic farmers combine both approaches. Technical adaptation and collaboration between farmers, government, and non-government organizations are essential to improve food security and welfare amidst climate change.

Keywords: Climate Change, Food Security, Rice Productivity, Farmer, Adaptation.

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1. Introduction

Extreme climate change is a global concern because of its impact on food security, especially in developing countries in Africa, Asia, and Latin America, which depend on the agricultural sector. A report by the International Food Policy Research Institute (IFPRI) predicts that by 2050, 16 million people will go hungry, and another 50 million will be undernourished due to climate change. Declining agricultural productivity is the most visible impact, triggered by rising temperatures and erratic rainfall patterns. Rising global temperatures reduce crop yields, while natural disasters such as floods and droughts exacerbate land degradation. Climate change causes significant yield reductions due to extreme temperatures and changes in rainfall patterns, which disrupt the growing season and increase pest and disease attacks (Sihombing et al., 2023; Valente, 2024). These impacts affect rice and a range of other food commodities, further threatening food security in vulnerable regions.

In addition, climate change has also resulted in a decrease in the quality of food consumption per capita and a decline in the quality of food commodities consumed. The Food Security Index (IKP) in 2021 noted that as many as 70 districts in Indonesia had low food security scores. This shows that the impacts of climate change are increasingly felt at the local level, especially in rural areas that rely heavily on the agricultural sector. In the agricultural sector, climate change causes seasonal shifts that disrupt planting schedules and increase the risk of crop failure. Rainfall variations, including a decrease in total rainfall and an increase in the frequency of extreme weather events, have been shown to impact rice production negatively. Decreased rainfall is correlated with decreased crop yields (Budathoki et al., 2022). In addition, flood and drought events, exacerbated by climate variability, directly affect rice yields, making production highly vulnerable to these changes (Joseph et al., 2023). Farmers in different regions must adapt to these challenges, but technological and resource constraints limit their adaptability.

Moreover, climate change is also increasing the cost of agricultural production. Climate extremes such as floods and droughts reduce crop yields and add to the cost burden of the recovery process and the use of resources such as labor and water. These increasingly uncertain conditions further stress farmers already in a vulnerable state. In addition to impacts on agricultural productivity, climate change also impacts the socio-economic conditions of rural communities. Decreased agricultural productivity results in reduced income and increased dependence on government assistance, exacerbating poverty and food insecurity (Fitriani et al., 2023; Rusmayandi et al., 2023). Increased vulnerability to natural disasters such as floods and droughts affects the economic stability of households that depend on agricultural products. As a result, the number of poor and food-insecure people continues to increase, especially in rural areas where the agricultural sector is highly vulnerable to climate change. Therefore, adaptation and mitigation efforts are vital in dealing with the impacts of climate change on the agricultural sector.

Adaptation to climate change includes adjustments to cropping patterns, efficient technologies, and better management of natural resources in analyzing how the impacts of climate change affect the agricultural sector, particularly on rice productivity, and how farmers respond to these challenges through adaptation to climate change. This study also aims to understand the differences in approaches between farmers using organic, semi-organic, and inorganic farming systems to mitigate climate change's impacts. By examining the social, cultural, economic, and technical aspects of farming, this research is expected to provide an overview of the most effective strategies to improve food security and farmers' welfare amid increasingly extreme climate change (Nasution et al., 2022).

2. Literature Review

The author collected some literature related to the theme of the discussion as a premise. Research shows that rice farmers in Kahama District adapt to climate change with drought-resistant seeds, irrigation modification, adjustment of planting time, soil conservation, water management, and climate information; they need further intervention for resilience (Zella & Lunyelele, 2024). This study discusses rice farmers' adaptation and mitigation models in Karanganyar Village, focusing on the differences in organic, semi-organic, and inorganic practices. In contrast, the study emphasized specific adaptation strategies without discussing differences in farming systems. Another study revealed differences in climate change awareness and adaptation strategies between highland and lowland rice farmers in Surallah, South Cotabato. Highland farmers were less aware and less adaptive, while lowland farmers were more moderate on both counts. Customized interventions are needed to improve their response to climate change (Baron, 2024). The difference in this study lies in the adaptation and mitigation strategies of organic, semi-organic, and inorganic rice farmers to climate change, which is different from those studies that only look at climate impacts broadly.

Another study discusses farmers' adaptation through a rice ratoon system that utilizes plant regeneration after harvest, reduces water use and greenhouse gas emissions, and increases yields and sustainability through variety management, planting time, and stem cutting (Maurya et al., 2023). The difference is that this study discusses the adaptation and mitigation of organic, semi-organic, and inorganic farmers to climate change. In contrast, the study focuses on rice ratoon systems to increase productivity and reduce emissions without comparing organic and inorganic farming systems. Then, the following study discussed the behavior of rice farmers in Soppeng in dealing with climate change through adaptation of agricultural technology, water management, wise use of fertilizers and pesticides, and knowledge of land and seed selection to reduce production and environmental risks (Malebbi et al., 2023). The difference is that this study discusses the adaptation and mitigation of organic, semi-organic, and inorganic wetland rice farmers. In contrast, the study focuses more on farmers' behavior in managing farming risks.

The results showed the importance of farmers adopting adaptation and mitigation strategies to deal with climate change, such as crop diversification, irrigation efficiency, climate-resistant varieties, and innovative farming practices for food security (Chauhan, 2024). The difference of this study lies in analyzing the adaptation and mitigation approaches of organic, semi-organic, and inorganic wetland rice farmers in Karanganyar Village, as well as the social, cultural, economic, and technical impacts of climate change. This study highlights the importance of adaptation and mitigation strategies in Indian agriculture to address the impacts of climate change through adjustments to agricultural practices and reduction of greenhouse gas emissions (Rao et al., 2024). This study differs because it compares adaptation and mitigation strategies among organic, semi-organic, and inorganic wetland rice farmers in Karanganyar Village, Beringin Sub-district, and Deli Serdang Regency. The research examines the social, cultural, economic, and technical aspects of farming, providing a comprehensive view of food security amid extreme climate change.

The research highlighted the need for field-level adaptation measures, including crop simulation models, agronomic practices, land and water management, and genetic improvement, to mitigate the impacts of climate change on agriculture and maintain yields, especially in vulnerable tropical regions (Singh, 2023). Other research identified Missouri farmers' adaptation and mitigation strategies to extreme weather. The main adaptation was increased land drainage, while mitigation involved reduced tillage. Key factors were crop type, income, and views on extreme weather (Skevas et al., 2022). Later research addressed climate change adaptation and mitigation in agricultural practices. Proposed adaptation strategies include crop diversification, conservation agriculture, and climate-resilient crop varieties. Mitigation includes efficient resource management through intelligent farming technologies and precision irrigation systems. The study also emphasized the importance of multi-stakeholder collaboration, using local knowledge, and strengthening farmers' capacity to build resilience to climate change to ensure global food sustainability (Naik et al., 2024).

The study examined the adaptation strategies of cassava farmers in Akwa Ibom, Nigeria, to climate change. Key strategies included mulching, organic fertilizer, and mixed cropping. Factors such as age, gender, income, and land size influenced the adoption of these strategies. It is recommended that local knowledge be integrated into climate change adaptation policies (Okon et al., 2024). Future research addresses farmers' adaptation strategies to climate change, such as crop diversification, precision agriculture technology, sustainable water management, and ICT use. Policy support and stakeholder cooperation are essential in improving agricultural resilience and long-term sustainability (Rajesh et al., 2024). Farmers recognize climate change as a new threat that affects agricultural yields. They apply adaptation through the use of pesticides, adjustment of the growing season, crop diversification, and mitigation through modern technology and sustainable land management (Adelina et al., 2024). This research addresses farmers' adaptation to climate change through Climate-Smart Agriculture (CSA), crop diversification, climate-friendly technologies, and extension support to improve resilience and productivity (Mishra et al., 2024).

The research combined social learning and behavioral modeling to understand farmers' adaptation to climate change in northern Italy. An Agent-Based Model (ABM) showed how risk preferences influence farmers' decisions regarding cropping patterns and irrigation methods, supporting regional adaptation strategies (Ricart et al., 2024). Climate change in Tharaka-Nithi County, Kenya, impacts women more than men. Farmers adopted various adaptation strategies, such as soil conservation and tree planting, with men having greater access to resources such as land and credit. The research recommends mainstreaming gender in climate change adaptation and mitigation efforts to reduce inequalities (Ndubi et al., 2024). The research explored vegetable and flower farmers' adaptation mechanisms to climate change, especially to extreme heat. Farmers adjusted work schedules, increased hydration awareness, and strengthened community collaboration to improve occupational safety and health sustainably (Denny & Tembalang, 2024).

3. Methods

The method used in this research is qualitative because the data regarding farmers' perceptions, knowledge, vulnerability, resilience, and adaptation behavior to climate change cannot be measured with certainty with quantitative indicators. Qualitative methods, particularly case studies, are relevant for understanding the socio-cultural and economic context and unique experiences of individual organic, semi-organic, and inorganic farmers in dealing with extreme weather changes. This approach allows in-depth exploration of context variations, farmers' knowledge and perceptions, and the subjective impacts of weather changes. In addition, qualitative methods assisted in identifying contextualized adaptation and mitigation models, as well as factors that influence the effectiveness of these strategies, through techniques such as in-depth interviews and participatory observation.

Data collection techniques included in-depth interviews to understand farmers' experiences and strategies, participatory observation to observe farming practices, documentation to complement and validate data, and desk research to build a theoretical framework and obtain additional information from relevant literature. Data analysis techniques in this study followed Norman K. Denzin's stages: data collection and familiarization, coding, and categorization according to social theory, search for theoretical themes, critical interpretation with links to social dynamics, and interpretive report writing to connect findings to the broader social context.

4. Results and Discussion

General Condition of Karanganyar Village, Beringin District, Deli Serdang Regency

Beringin Sub-district is one of the sub-districts located in Deli Serdang Regency, North Sumatra Province. Astronomically, the Beringin Sub-district is located between 3°54 - 3°62' North latitude and 98°83' - 98°88' East longitude, with an altitude of between 8 - 15 meters above sea level. The area of Beringin Sub-district is 54.32 km2 or about 2.17% of the area of Deli Serdang Regency (2,497.72 km2) (Deliserdangkab.bps.go.id, 2023). Beringin Sub-district has an area of 52.69 km2 or 5,269 Ha consisting of 11 villages and 89 hamlets; the Sub-district Capital is located in Karang Anyar Village with earth coordinates of 3.608620º North Latitude (LU) and 98.88937º East Longitude (BT). The area of Karang Anyar Village is 463.40 hectares, most of which is used as agricultural land. The land area used for rice fields is 194 hectares, or 41.9% of the total village area (Sudarwati et al., 2024).

Karang Anyar Village is administratively divided into eight hamlets. The administrative boundaries of the village are as follows: Beringin Village and Sidoarjo Ramunia Village to the north, Sidodadi Ramunia Village to the south, PTPN IX/PT Angkasa Pura Kualanamu Airport to the west, and Serdang Bedagai Regency to the east. The majority of land in Karanganyar Village is still designated for agriculture, with a paddy field area of around 14.87% and settlements of 18.40% of the total land in 2022 (Jannah & Taryono, 2024).

Irrigation Conditions in Karang Anyar Village

Karang Anyar Village on the eastern side is drained by two rivers: the Kenang River and the Ular River. The management of these river water resources is carried out by making irrigation channels. The main irrigation channel in Karang Anyar Village is the Ramunia Sunday, and it serves approximately 2300 hectares of agricultural land sourced from the Ular River weir. The irrigation channels consist of primary, secondary, tertiary, and worm channels. Each of these channels has an officer in charge of checking the water flow in the channel. Floodgate guards monitor primary, secondary, and tertiary channels under the Ministry of Public Works and Spatial Planning - Sumatra River Basin Center (PUPR BWSS). Worm drains are monitored by the Water User Farmers Association (P3A), which the agriculture office fosters. This ensures that water availability for agricultural land in Karang Anyar Village is always maintained and increases water use efficiency. So that the cropping pattern can be organized, namely rice - rice - secondary crops, it is essential to keep the river clean from waste. This is done to ensure the availability of sufficient clean water for agricultural land.

Demographic Situation

In 2022, the total population of Karang Anyar Village reached 9,419 people. This village has a population density of 2,034 people/km² with 4,705 men and 4,714 women (Deliserdangkab.bps.go.id, 2023). Based on age composition, the population of Karang Anyar Village consists of 2,477 people (26.6%) in the young age group (0-14 years), 6,013 people (64.6%) in the middle age group (15-59 years), and 813 people (8.7%) in the elderly group (60 years and over). This composition illustrates that most of the population is of productive age, with the potential to be actively involved in education and employment. In terms of religion, the majority of the population of Karang Anyar Village is Muslim, totaling 9,125 people, while 80 people follow Christianity, and 11 people are Catholic (Sudarwati et al., 2024).

Livelihood Structure and Composition of Farmers by Land Area in Karang Anyar Village

The agricultural sector dominates livelihoods in Karang Anyar Village, with 1,109 people (15.8%) working as farmers, farm laborers, or farm business owners. However, there are also other sectors, such as animal husbandry (3.1%), fisheries (0.4%), private employees (5.4%), and small industries and household crafts (0.8%). A total of 873 people (12.5%) were involved in other self-employment, while 1,628 people (23.2%) were students, and 2,478 people (35.4%) were not yet employed. This reflects that the agricultural sector is still the mainstay of the village economy, supported by the availability of abundant natural resources. However, challenges in creating employment still need to be overcome. The main agricultural commodity in Karang Anyar Village is paddy rice, cultivated on an area of 290 hectares with productivity reaching 9 tons per hectare. Rice was chosen as the primary commodity due to the village's location on the Ular River, which ensures that the water needs for irrigation are always met. Almost all farmers in the village own paddy fields, although the size of the fields varies (Sudarwati et al., 2024).

Table 1. Data on the Number of Farmers Based on Land Area

Land Area (Ha)	Number of Farmers (people)	Percentage (%)
Tidak memiliki lahan	98	13,8
0,1 – 0,2	264	37,3
0,21 – 0,3	76	10,7
0,31 – 0,4	125	17,7
0,41 – 0,5	28	4,0
0,51 – 0,6	52	7,3
0,61 – 0,7	8	1,1
0,71 – 0,8	25	3,5
0,81 – 0,9	2	0,3
0,91 – 1,0	2	0,3
1,1 – 3	28	4,0
Total	**708**	**100**

Source: Author, 2023

Based on the data, most farmers (37.3%) own between 0.1 and 0.2 hectares of land, indicating the limited land owned by farmers in this village. However, the data also shows that 98 farmers (13.8%) do not have land, so they must borrow land to grow rice. This condition poses a challenge for landless farmers, as they depend on borrowing land from other owners to work. Usually, this land loan is done by paying 50 kg of dry grain per one rate of land borrowed. This situation emphasizes the need for solutions to improve farmers' welfare with limited or no land.

Farmers' Knowledge of Climate Change

Climate change is a global phenomenon that significantly impacts the agricultural sector, especially for wet rice farmers in Indonesia. Increasingly erratic weather, rising temperatures, and changes in rainfall patterns and seasons have forced farmers to change how they farm. Farmers face various challenges, including financial constraints and unpredictable seasonal rainfall, which disrupt traditional farming methods (Pokiya et al., 2024). This section discusses farmers' knowledge of climate change, including their perceptions of signs of extreme weather changes, the duration of perceived climate change, and the sources of information farmers use.

Signs of Climate Change Observed by Farmers

Based on interviews with different types of farmers (organic, semi-organic, and inorganic), various signs related to climate change have been observed. The following table illustrates farmers' knowledge of climate change and their ability to predict the weather.

Table 2. Matrix of Farmers' Knowledge and Perception of Signs of Climate Change

Category	Knowledge & Perception of Climate Change	Predictive Ability	Source of Information
Organic Farmers	Changes in cropping patterns, erratic rain	Difficult to predict	Personal observation, BMKG
	High temperature, irregular rainfall	Inaccurate	Personal observation, not BMKG
	Abnormal rainfall, flooding	Using environmental signs	School, personal experience
	Limited knowledge, unpredictable weather	Difficult to predict	Personal observation, extension worker
Semi-Organic Farmers	Difficulty predicting seasons, wind increases	Being aware of discomfort	Extension worker, personal observation
	Lots of rain, hard to predict weather	Using BMKG	Media, extension workers, access to technology
	Basic understanding, traditional signs	Difficult to predict	Personal experience, discussion
	Impact of deforestation, erratic weather	Inaccurate	Personal experience, discussion
An-Organic Farmer	Basic awareness, unpredictable weather	Relying on BMKG	BMKG media, personal experience
	Two main seasons, pest problems increase	Using personal experience	TV, government information
	Traditional calendar, unpredictable weather	Using traditional knowledge	Radio, calendar, discussion
	Limited knowledge, heatwave	Difficult to predict	Personal observation, discussion
	Basic awareness, temperature and wind increase	Using personal experience	Observation, limited information
	Basic knowledge, erratic weather	Relying on personal experience	Personal experience, discussion
	Limited knowledge, erratic weather patterns	Difficult to predict	Personal experience, feedback
	Limited knowledge, seasonal pest problems	Difficult to predict	Personal experience, discussion
	Basic awareness, unpredictable weather	Difficult to predict	Personal experience, discussion

Source: Author, 2023

From this table, wet-rice farmers in Karang Anyar Village have various knowledge, perceptions, and predictive abilities towards climate change, which differ based on the type of farming they practice. Organic farmers generally have a deeper understanding of climate change, attributing it to erratic cropping patterns and rainfall, although they still struggle to predict the weather. Semi-organic farmers have more basic knowledge and often rely on traditional signs and personal experience to understand weather changes, although they also experience difficulties in prediction. Meanwhile, inorganic farmers, with more limited knowledge, focus more on increasing temperatures and pest problems and rely on personal experience and limited sources of information, leading to difficulties in predicting volatile weather patterns.

Farmers' Perceptions of the Causes of Climate Change

Most farmers believe that human activities, including chemical fertilizers and deforestation, contribute to climate change. They consider deforestation the leading cause of climate change, with 75% recognizing its impact (Gbawoquiya & Cherif, 2022). However, some attribute it to supernatural factors. These perceptions depend mainly on the type of farming system practiced and the level of education.

Table 3. Farmers' Perceptions of the Causes of Climate Change

Type of Agriculture	Perceptions of the Causes of Climate Change
Organic	1. Human activities, such as the use of chemical fertilizers and waste burning that increase greenhouse gases. 2. Human activities, especially the overuse of chemicals in agriculture. 3. Human activities, especially the use of chemical fertilizers and deforestation that cause climate change. 4. God's will, considering weather changes as part of the Divine plan.
Semi-Organic	1. Climate change is caused by human activities such as deforestation and chemical use. 2. Excessive use of chemical fertilizers causes weather and climate change. 3. Does not give a specific opinion, but recognizes the impact of human activities on the environment. 4. Human activities, especially deforestation and the use of chemicals in agriculture affect the weather.
An-Organic	1. Deforestation and overuse of chemicals in agriculture have an impact on climate change. 2. Climate change is caused by human activities, including the use of pesticides and chemicals in agriculture. 3. Human activities such as the use of chemicals in agriculture cause extreme weather changes. 4. No specific opinion, but recognizes that climate change is happening. 5. The use of chemicals in agriculture has an impact on the weather, although not sure about the details of the impact. 6. Human activities, especially land use change and chemical use are causing climate change. 7. No opinion on agricultural activities, but aware of climate change. 8. Climate change is caused by human activities, especially the use of chemicals in agriculture. 9. Recognizes that human activities, including chemical use, contribute to climate change.

Source: Author, 2023

Organic farmers tend to be more aware of the impact of human activities, such as chemical fertilizers and deforestation, on climate change. They understand that unsustainable agricultural practices contribute to the phenomenon. Semi-organic farmers are also aware of the negative impacts of chemical use and deforestation, although their level of understanding may be slightly more limited. Meanwhile, an-organic farmers show variations in their perceptions; some are aware of the impact of human activities on climate change, while others are more confused or doubtful, with most still attributing weather changes to the use of chemicals in agriculture. However, some farmers hold the view that climate change is part of God's will or destiny, suggesting that this perception is influenced by each farmer's cultural background and education level.

Sources of Information and Impact of Climate Change on Agriculture

Climate change poses significant challenges for farmers in Indonesia, and farmers' knowledge and understanding of weather and climate change are strongly influenced by the sources of information they access. Some farmers get information from official institutions such as BMKG and PPL, while others rely more on personal experience or discussions with fellow farmers. Information from government sources and research institutions significantly improves farmers' adaptation behavior, increasing their awareness and decision-making on climate change (Liu et al., 2023). Access to technology and mass media is also essential, especially for farmers who use information from TV, radio, or social media. Combining these sources helps farmers decide to adjust their farming methods in an increasingly uncertain climate. The impact of climate change on agriculture varies greatly depending on the type of farming system used.

Organic, semi-organic, and inorganic farmers face different challenges related to climate change, including decreased production, pest infestation, and additional maintenance costs. Extreme weather, such as erratic rainfall, strong winds, and high temperatures, reduces yields, while pests, such as leafhoppers, are difficult to control. Farmers with access to information and technology are better equipped to cope with the impacts of climate change than those who rely on traditional methods.

Table 4. Information Sources and Climate Change Impacts

Type of Agriculture	Source of Information	Climate Change Impacts
Organic	PPL, LSM PANSU, BMKG	Decreased production due to uprooted rice due to strong winds and rain, failure to grow secondary crops for several years, additional costs to tie up up uprooted rice.
Organic	LSM PANSU, Personal experience	Production has declined due to erratic rainfall and higher temperatures, difficulty in predicting the weather, and more frequent pest attacks.
Organic	Field School, Discussion with fellow farmers	Unstable rainfall led to flooding in the highlands, many damaged crops, an increase in pests that destroy rice plants.
Organic	LSM PANSU, PPL	It is difficult to predict the weather, crop yields have decreased due to irregular rains and increased wind intensity.
Semi-Organic	PPL, Social Media, LSM PANSU	Decreased production due to erratic rains, pest infestation, increased costs for pesticides and crop treatments during the rainy season.
Semi-Organic	PPL, Mass Media, LSM PANSU	Increase in pests such as leafhoppers during the rainy season, reduced crop quality, increased pesticide costs, multiple crop failures.
Semi-Organic	Discussion with fellow farmers, LSM PANSU	Decreased production due to more pests during the rainy season, unstable rainfall, increased pesticide costs and additional labor.
Semi-Organic	PPL, Personal observation	Failure of secondary crops due to extreme weather, erratic rainfall, many rice paddies damaged by wind and heavy rain, more intensive pest attacks.

An-Organic	Mass Media (BMKG, TV), Personal experience	Increased pest attacks during the rainy season, rice plants uprooted by strong winds, yield reduction of up to 30%, increased pesticide costs.
An-Organic	TV Information from Local Government, BMKG,	Difficult to predict the weather, decreased production due to strong winds and erratic rainfall, increased pesticide and labor costs, multiple crop failures.
An-Organic	Radio, Discussion with fellow farmers	Increased pest attacks during the rainy season, additional costs for pesticides, decreased production due to unstable rainfall, decreased crop quality.
An-Organic	Personal experience, Community discussion	Production has declined due to extreme weather, many rice fallen due to strong winds, increased maintenance costs, more intensive pest attacks during the rainy season.
An-Organic	Personal experience, Discussion with fellow farmers	Difficulty predicting the weather, increased planthopper infestation, rice often falling due to strong winds and heavy rain, increased pesticide costs, reduced crop quality.
An-Organic	Community discussion, Personal experience	Yield reduction of up to 40% due to strong winds and rain, additional cost of tying up fallen paddy, increased pest infestation during the rainy season, reduced crop quality due to pest infestation.
An-Organic	Community discussion, Personal experience	Difficult to predict the weather, increase in planthoppers during the rainy season, many rice paddies damaged due to erratic rainfall, increased costs of pesticides and additional labor, significant decrease in production.
An-Organic	Community discussion, Personal experience	Increased pest infestation during the rainy season, additional costs for pesticides, frequent uprooting of rice plants due to strong winds, reduced crop quality.
An-Organic	Community discussion, Personal experience	Difficulty predicting the weather, more frequent pest attacks during the rainy season, decreased production due to fallen rice, increased pesticide costs, many crops damaged by wind and rain.

Source: Author, 2023

The table reveals that farmers' knowledge and perception of climate change varies based on their farming type. Organic farmers generally have a deeper understanding of climate change and often link it to chemical fertilizers and deforestation, but they still have difficulty predicting the weather. Semi-organic farmers, while relying more often on traditional signs and personal experience, are starting to pay attention to the impacts of climate change and rely on information from agricultural extension workers. In contrast, inorganic farmers, with more limited knowledge, often face difficulties predicting the weather and attribute climate change to increased temperatures and pest problems. Awareness of the causes of climate change generally includes human activities. However, some attribute it to supernatural factors or god's will, suggesting differences in perceptions influenced by cultural background and education level.

Farmers' Adaptation Model to Extreme Weather Changes

Extreme weather changes characterized by increased frequency and intensity of phenomena such as floods, droughts, and seasonal patterns have become a significant challenge for farmers worldwide, including Indonesia. An analysis of drought patterns shows that a prolonged dry season threatens agricultural sustainability and food security (Syakirin & Sayfuddin, 2024). Erratic rainfall and temperature changes disrupt traditional growing seasons, leading to reduced yields and increased prevalence of pests and diseases (Sihombing et al., 2023). Climate change's impacts significantly affect

Indonesia's agricultural sector, especially for rice farmers. Farmers face severe challenges in maintaining production due to unpredictable weather changes. To overcome this, farmers apply different adaptation models based on the farming systems used, organic, semi-organic, and inorganic, with approaches that vary in socio-cultural, socio-economic, and technical aspects. This chapter discusses how farmers adapt and the models applied to maintain farm sustainability (Sinaga et al., 2022; Thamrin et al., 2024).

Socio-cultural Adaptation Model

Socio-cultural adaptation includes how farmers use local values, traditions, and cultural wisdom in dealing with extreme weather changes. In many agrarian communities in Indonesia, especially in rural areas, traditions and cultural practices play an essential role in decision-making related to agricultural activities. Organic farmers generally adhere more to traditional values when dealing with extreme weather. One example is "Pranata Mangsa," a traditional Javanese calendar system that determines planting times based on weather cycles. Organic farmers often perform traditional rituals such as "wiwitan," which is done before planting as a form of respect for nature and to ask for a blessed harvest. They also tend to pay more attention to the balance of the ecosystem and do not use chemicals that can damage the soil. Organic farmers are trying to build long-term resilience to climate change by maintaining ecological sustainability. These practices show how cultural and ecological values go hand in hand in shaping their adaptation strategies to extreme weather.

While still tied to some local traditions, Semi-organic farmers are starting to integrate modern approaches into their practices. They follow village meetings to determine the optimal planting time based on weather conditions. However, they also utilize information from the media or extension agencies such as PPL (Penyuluh Pertanian Lapangan). This flexibility in combining local traditions and modern approaches allows semi-organic farmers to be more adaptive to unpredictable weather changes while still maintaining cultural heritage. In contrast, inorganic farmers rely less on traditional cultural values. They rely more on technology and input from outsiders, such as the government or agricultural extension workers, to determine when to plant and how to manage the land. Inorganic farmers often make decisions based on short-term efficiency, focus on mass production, and ignore environmental sustainability. While this model can provide quick results, the high dependence on chemical inputs and modern technology makes them more vulnerable to long-term risks from extreme weather changes.

Socio-economic Adaptation Model

Socio-economic aspects also play an essential role in farmers' adaptation strategies to extreme weather changes. Socio-economic adaptation includes how farmers manage their economic resources in uncertain weather conditions. Organic farmers tend to be independent in managing their farm economy. They avoid dependence on expensive chemical inputs and prefer to use local resources such as organic fertilizers and home-made vegetable pesticides. In addition, organic farmers often sell their agricultural products to organic markets that provide higher prices, such as organic rice, which can reach IDR 15,000 to IDR 16,000 per kilogram. The success of organic farmers in dealing with extreme weather is also supported by sound financial management. They save their harvests to deal with difficult times, such as droughts or floods that can damage crops. In addition, they tend not to rely on loans or credit, thus reducing the risk of default when there is a decline in production due to extreme weather. This financial independence helps organic farmers maintain their farms' stability in the long run.

Semi-organic farmers fall somewhere in between, utilizing both local resources and external inputs. Semi-organic farmers often use subsidized chemical fertilizers from the government but are also starting to switch to organic fertilizers to maintain soil fertility. They have greater economic flexibility than organic farmers but still rely on external assistance such as subsidies and help from cooperatives or the government. This flexibility allows them to adapt quickly to weather changes, but they must still manage the risks of dependence on chemical inputs and government assistance. In contrast, inorganic farmers rely heavily on government subsidies, primarily for chemical fertilizers and pesticides. This dependency makes them more vulnerable to market price fluctuations and changes in subsidy policies. Inorganic farmers often borrow capital to purchase farm inputs, which adds to their financial burden if extreme weather causes crop failure. To reduce the risk of loss, inorganic farmers usually sell their crops as soon as possible, without waiting for prices to rise in the market, for fear of crop damage due to erratic weather.

Farming Technical Adaptation Model

Technical adaptation involves using agricultural technologies and practices that can help farmers overcome extreme weather challenges. Organic farmers focus more on environmentally friendly technologies. They use organic fertilizers, plant-based pesticides, and efficient irrigation systems to reduce chemical dependence. Organic farmers also tend to select crop varieties resistant to weather changes, making them better able to withstand drought or high rainfall conditions. Semi-organic farmers adopt a mixed approach, using modern technology such as tractors and jajar legowo planting systems to improve land and water use efficiency. They also try to gradually reduce the use of chemical fertilizers, replacing them with organic fertilizers. Although not yet completely free from dependence on chemical inputs, semi-organic farmers are making more vigorous efforts to keep their farms sustainable amidst extreme weather challenges.

In contrast, inorganic farmers rely heavily on chemical inputs and modern technology. They use pesticides and chemical fertilizers intensively to maintain high yields, even though this increases the risk of environmental damage in the long run. Their technologies focus on short-term production efficiency but ignore long-term impacts such as soil degradation and fertility decline. The high dependence on chemicals makes inorganic farmers more vulnerable to losses in unexpected weather changes, such as excessive rainfall or prolonged drought.

Table 5. Farmer Adaptation Model to Extreme Weather Changes

Type of Agriculture	Socio-cultural Adaptation	Socioeconomic Adaptation	Technical Adaptation of Farming Business
Organic	Using Pranata Mangsa and wiwitan rituals	Saving for hard times, selling organic rice at high prices	Making compost fertilizer, using weather-resistant varieties
Organic	Banning straw burning, protecting natural enemies of pests	Sell produce to organic markets, independent in financial management	Using plant-based pesticides, efficient irrigation systems

Semi-Organic	Village meeting to determine planting schedule	Relying on chemical fertilizer subsidies, savings and access to credit	Jajar legowo planting system, using a tractor and compost fertilizer
Semi-Organic	Avoiding straw burning, maintaining ecosystem balance	Income diversification, utilizing government assistance	Reduce chemical fertilizers, increase the use of organic fertilizers
Inorganic	Not involved in local traditions, focused on short-term efficiency	Dependent on chemical fertilizer subsidies, often borrow capital	Intensive use of chemical fertilizers, application of agricultural mechanization to increase efficiency

Source: Author, 2023

The table illustrates three models of farmers' adaptation to extreme weather changes based on their farming systems: organic, semi-organic, and inorganic. Organic farmers utilize traditional values such as Pranata Mangsa and maintain ecosystem balance through environmentally friendly practices, with high economic independence and use of natural technologies. Semi-organic farmers combine traditional and modern approaches, utilizing government subsidies and agricultural technology to improve efficiency, although still relying on chemical inputs. Meanwhile, inorganic farmers rely more on modern technology, subsidies, and external inputs, focusing on short-term production, but are more vulnerable to environmental risks and extreme weather changes.

5. Conclusion

This study analyzed the adaptation and mitigation models of wet-rice farmers in Karanganyar Village, Beringin Sub-district, and Deli Serdang Regency, who face climate change impacts. The results show that extreme weather changes, such as erratic rainfall, increased temperatures, and a high frequency of pest attacks, have affected agricultural productivity in the region. Organic, semi-organic, and inorganic rice farmers show differences in their approach to adaptation to these challenges. Organic farmers focus more on ecosystem sustainability by utilizing local wisdom, such as organic fertilizers, plant-based pesticides, and efficient irrigation systems. They also tend to be more economically independent by selling their produce to specialized organic markets that offer higher prices. In contrast, inorganic farmers rely more on chemical inputs, such as fertilizers and pesticides, and modern technology to increase production. However, this reliance on chemicals increases the risk of long-term environmental damage. Semi-organic farmers fall in between these two approaches by combining chemical inputs, modern technology, and some environmentally friendly practices.

Socio-cultural and socio-economic adaptations also play an essential role in dealing with climate change. Organic farmers generally utilize traditional values and rituals to determine planting times. In contrast, semi-organic and inorganic farmers rely more on modern technology and information provided by the government and related institutions. Economically, organic farmers tend to be more self-reliant by carefully managing their finances and saving their harvests for extreme weather. On the other hand, inorganic farmers are more financially vulnerable due to dependence on government subsidies and credit to purchase agricultural inputs. Therefore, technical adaptations, such as crop diversification, weather-resistant varieties, and efficient water resource management, are essential to mitigate climate change's negative impacts. This research emphasizes the need for collaboration between farmers, government, and non-governmental organizations to improve farmers' adaptive capacity to maintain their food security and welfare amid the increasingly complex threats of climate change.

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